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'UNIFIED': Bridging the Researcher-Practitioner Divide in Mind, Brain and Education

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Abstract:

Mind, Brain and Education Science is by definition transdisciplinary. However, the communication and collaboration between constituent disciplines needed for true transdisciplinarity remains relatively rare. Consequently, many of the potential benefits of MBE science remain unrealised for parties on all sides of the discipline. The present commentary first conducts an analysis of the current Strengths, Weaknesses, Opportunities and Threats of transdisciplinary partnerships in MBE. A new, free, and international web platform ('UNIFIED') is then proposed to broker relationships between researchers and teachers within schools. This website would allow users to form collaborations based on a system of tags indexing their research interests as well as practicalities such as their location. Such a website appears well placed to realise many of the opportunities, and mitigate the threats and weaknesses, of transdisciplinary MBE research. The article concludes with an appeal to interested researchers and schools to contribute to the development of the project.

Keywords: Neuroscience, Psychology, Education, Interdisciplinary research, Interdisciplinary communication

Introduction

Mind, Brain and Education science aims at gathering knowledge from psychology (the study of the "Mind"), neuroscience (the study of the "Brain"), and educators' expertise about pedagogy, in the hope to better understand and promote learning (Samuels, 2009; Tokuhama-Espinosa, 2010). Tokuhama-Espinosa (2010) offers three practical goals for MBE professionals to achieve this aim:

- First, knowledge must be shared outside of parent disciplines, across the whole field. For example, educators feeling empowered to suggest research questions in psychology and neuroscience.
- Second, a common vocabulary should be employed to improve transdisciplinary communication.
- Third, MBE professionals must be open to adapting their own practice in light of information from all disciplines, rather than just from their own field. For example, psychologists and neuroscientists need to be open to adopting and adapting their research practices in light of the needs of teachers.

In light of these goals, MBE science cannot fulfil its stated aims as a transdisciplinary endeavour (Leavy, 2016) unless information sharing and expertise is a three-way process, with strong, reciprocal 'bridges' between each field (Coldwell et al., 2017; Stafford-Brizard, Cantor & Rose, 2017). Despite a growing enthusiasm from the education community (Pickering & Howard-Jones, 2007), many teachers lack confidence and/or skills in research (Coldwell et al., 2017), and many in the neuroscience community fail to link their work to real classrooms (Rose, Daley & Rose, 2011). Bodies such as the Organisation for Economic Co-operation and Development (OECD) have recently begun to recommend that teachers' pedagogical knowledge contains an understanding of the neuroscience of learning processes (Guerriero, 2014), and the engagement of schools and teachers with research now forms a part of the new school inspection framework in the UK (Ofsted, 2019). However, this can easily result in one-way models of communication where information is 'transmitted' from research to practitioners, thus falling short of the transdisciplinary goals of MBE science. To further complicate matters, vocabulary barriers still exist, with scientists and teachers using the same term to describe different ideas, or different terms for the same idea (della Chiesa, Christoph, & Hinton, 2009).

In this commentary the authors, a multi-disciplinary group of teachers, psychology and neuroscience researchers and school psychologists who formed at the EARLI SIG22 conference (London, June 2018) will explore the current state of transdisciplinary MBE science. Drawing on this analysis, we will then introduce a proposal for an online platform ('UNIFIED') to assist in brokering relationships between teachers and researchers. We believe that an increased partnership between these professional bodies would contribute to the construction of much needed bridges in MBE, and might allow for some of the as yet untapped potential of transdisciplinary MBE research to be realised.

Formation of a multi-disciplinary working party

The final day of the EARLI SIG22 conference in June 2018 was designated as an 'OpenSpace' meeting. An OpenSpace meeting format involves the formation of discussion groups based on agendas suggested by participants at the beginning of the process (see Owen, 2008). Discussion topics were invited around the general question of 'What can we all do to work together better and improve learning?'. Session titles were suggested by attendees and then displayed on post-it notes at a central display, with attendees selecting a discussion topic which most appealed to them in each time slot. Two of the authors proposed similar discussion topics, which were amalgamated into a single session entitled ‘Would it be useful to create a database of researchers and schools for educational research?’ The authors of the present article are all drawn from this original group.

The discussion group began with a round of contributions in which the attendees described their own specific goals and needs for transdisciplinary MBE communication, and the current challenges in achieving these. For example, two of the teacher co-authors reported that they had attended the conference in order to obtain “easier access to research and academic expertise”, and described their challenges in attaining this through other methods. This approach allowed the group to combine multiple perspectives and to synthesise ideas that would satisfy multiple user needs. One unanimous point of agreement from all contributors was a desire for improved communication between fields within MBE science. One co-author, founder of an influential organization designed to transmit research findings to teachers (‘The Learning Scientists’), noted that she commonly hears teachers bemoan the lack of a ‘matchmaking’ service to connect researchers and teachers with shared interests and knows researchers struggle to gain access to schools for research, with many schools located near institutions of higher education over saturated with active research.

Having identified the most common issues across fields and a shared desire for improved inter-disciplinary communication, the group next conducted a ‘gap analysis’ which brainstormed the group’s knowledge of existing tools designed to MBE communication across disciplines, and the extent to which these tools were able to address the issues previously raised. On the suggestion of one group member who had recent experience of a public engagement training session, the tools were divided into three categories according to the aims of the tool (Science for all, 2010). These were: **transmit** (tools aiming to transmit academic findings to others), **receive** (tools specifically designed to allow transmission of public - or in our case teachers' - knowledge back to researchers), and **collaborate** (tools aiming at joint creation of knowledge or shared participation).

The results of this analysis can be seen in Table 1. Following the conference, a more comprehensive survey of existing resources was also carried out by the authors, including online appeals to both researchers and educators for MBE tools which they found useful (for example appeals over social networks for "resources that amplify teachers' views and suggestions for research projects" and "resources to transmit research findings to educational practitioners". This added a further six tools (Table 1, italic text). As can be seen from Table 1, whilst there are numerous resources theoretically available within the MBE sphere, few primarily encourage collaboration between parties (especially between parties from different fields, rather than collaboration and sharing within a field, such as teachers sharing expertise through Twitter chats, for example) and even fewer are designed to facilitate knowledge transfer from practitioners to researchers, which is required for true transdisciplinary research. One exception was the existence of 'Research Schools' in both the US (e.g. Hinton & Fischer, 2008) and the UK (e.g. EEF/IEE Research Schools network), which aim to promote teacher-led implementation of research findings, sensitive to the needs of the practitioners. Whilst the aim of these institutions is to be applauded, they are expensive, rare (only 22 research schools currently exist in the UK), linked only to one specific centre and, perhaps most importantly, are still not explicitly designed to facilitate bidirectional communication between all parties.

Table 1. Summary of ‘gap analysis’ of the roles of existing MBE tools		
Transmit - To inform, educate, inspire or change the decisions of others (e.g. the public)	**Collaborate** - To create or decide something together with the public, drawing on each other’s expertise	**Receive** - To actively listen to, and to use, the views, skills, and knowledge of the public.
Research Schools (UK and International)		
o **Post-hoc training for teachers**: - MOOC The Science of Learning - IMBES program - *Neuroteach Global* - *BrainU - Neuroscience for teachers and students* - *School research-leads (e.g. RISE project)* o **Conferences/Seminar series**: - International Mind, Brain and Education Society (IMBES) - European Association for Research on Learning and Instruction (EARLI) - Educated Brain Seminars (Cambridge University) - CEN Educational Neuroscience Seminars (Birkbeck, UK) - ResearchED o **Publications**: - Mind, Brain and Education* - The Psychologist* - Impact - Bold blog for the Jacobs Foundation - NPJ Science of Learning - *Learning and Instruction** - *inTuition - Society for Education & Training* o **Organisations / Websites**[1]:	o **Training “Neuroeducators”**: - Mind, Brain and Education course at the Harvard Graduate School of Education - Other Mind, Brain and Education courses o **One-shot events**: - Third-space: Science of Learning o **Collaborative platform**: - School Participatory Action Research Collaborative (e.g. Kurilloff et al., 2009) - TeacherLed RCTs - *Lab School Network in Paris, now closed due to a lack of funding.* o **Twitter/Facebook chats**: - #LrnSciChat - *#ASEchat* - *#cogscisci*	

- What Works Clearinghouse - Education Endowment Foundation - Learnus - Learning Scientists - Retrievalpractice.org - Deans For Impact - The Learning Agency - Institute for Effective Education - *I'm a Scientist, get me out of here!*		

Table 1. Normal text indicates tools referenced the the working party in the initial 'OpenSpace' discussion session. *Italic text* indicates tools added subsequently following appeals by authors to researchers and teachers. * Requires an academic subscription. [1] Many of these websites encourage exchange of ideas across disciplines, and could at times be categorized in the "collaboration" section of this table, however they are categorised here according to their primary function.

Many other resources take a 'transmission' approach which, whilst often laudable in aim and valued by teachers, does not consistently allow for practitioners to feed their expertise back into the research process. Others, whilst ostensibly aimed at encouraging interaction between disciplines may disadvantage particular groups because of the time or travel commitments required to participate. For example, academics will often be more easily able to attend conferences and meetings, even when these are also aimed at teachers. One teacher co-author commented:

"I have attended conferences and meetings intended to be the interface with researchers and teachers and been the only teacher speaking or one of only a few teachers attending"

From the process above, the idea for a network that would facilitate **bi-directional** communication between researchers and practitioners was born. It was observed that such communication, in theory, formed one of the central aims of transdisciplinary MBE science (Tokuhama-Espinosa, 2010). However the unanimous view of the group was that this goal was not being adequately met (a view that would seem to be supported by Table 1).

Further development

Following the EARLI meeting in June 2018, a working group was established to move the project forward. Eleven people from six countries joined through Zoom teleconferencing in a number of meetings which progressed according to three main aims (which ran concurrently). First, there was a recommitment to the project by each member and offers of specific areas of expertise. Second, the group contributed to a literature review (see below) to ensure that the design was based on evidence-based practice. Third, working groups were created to design an online platform aiming at answering the needs identified through the SWOT analysis ('System Design' section). Additionally, actor perspectives (primarily teachers and researchers) were fielded informally for feedback about the general design and ongoing progress.

SWOT analysis of transdisciplinary research in MBE science

This initial overview of MBE communication tools (Table 1) suggests a paucity of tools which facilitate true transdisciplinary communication. Given that reciprocal communication is central to the aims of MBE science, this appears concerning. However, there may well be good reasons why transdisciplinary models are not always employed. Indeed, it can easily be imagined that the costs associated with transdisciplinary research have been found by MBE practitioners to outweigh the benefits. It was determined, therefore, to conduct a review of the existing MBE literature, to assess the extent and success of current efforts to facilitate transdisciplinary MBE research. Given the diverse perspectives of the working party, we were able to go beyond a simple literature review on the current state of transdisciplinary MBE science, and to organise the review using a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis.

The SWOT analysis methodology emerged in the 1960s at a Stanford University Research convention focused on business project planning (Humphrey, 2005). When conducted with a group of diverse actors, a SWOT analysis permits multiple perspectives on a condition or problem, as well as a critical review of not only the existing evidence but also of the potential benefits and pitfalls of application. The methodology allows users to advance the decision-making process in an evidence-based way that takes into account multiple perspectives. The best decisions are made when they are based on evidence (Stiggelbout, Pieterse & De Haes, 2015) and when decision-making takes input from multiple stakeholders (Payne & Calton, 2017). Of special relevance to the current project, decisions about new or creative endeavors also specifically benefit from ideas that emerge from the amalgamation of multiple actor perspectives (Paulus & Nijstad, 2019). The SWOT methodology therefore allowed us to derive maximum benefit from the diverse specialisms and expertise within our working group.

While SWOT analyses have traditionally been applied to businesses and governments to evaluate trends, policies and to conduct future planning, SWOT analyses have more recently been applied to other contexts, such as healthcare and bioethics (van Wijngaarden, Scholten & van Wijk, 2012), education (Romero-Gutierrez, Jimenez-Liso & Martinez-Chico, 2016), and university governance (Luo & Qin, 2012). A SWOT analysis was carried out in this to meet this aim by first conducting a collaborative literature review, in which members of the working party contributed articles which they considered illustrative of at least one of the three aims of transdisciplinary MBE research quoted in the introduction (Tokuhama-Espinosa, 2010). This provided 55 research articles, book chapters and conference papers. Although the articles were considered as illustrating the goals of MBE science, they were not drawn exclusively from the MBE literature. As the focus of this paper is on unifying researchers and practitioners, independent of the tools they use, and not limited to MBE, we chose to allow a wider selection of articles. In addition, a central facet of transdisciplinary MBE is to give equal weight to evidence from different methodological structures. We therefore determined not to prioritise evidence from the neuroscience literature above other sources.

Drawing on established approaches for conducting systematic reviews (e.g., Popay et al., 2006), the lead author subsequently conducted an additional review for further material, searching the PubMed, PsycInfo and Google Scholar databases using the following keywords taken separately or in combination: transdisciplinary, multidisciplinary, interdisciplinary, education, psychology, neuroscience. Only articles published before August 2018, which had not previously been contributed by the working party, were considered for selection. Article selection for analysis was further based on whether the work attempted to achieve at least one of the three aims of transdisciplinary MBE research (as above). This process added 11 research articles. Finally, according to our multiple perspectives, the authors collaboratively arranged the articles according to the SWOT methodology. Rules for categorisation were that Strengths and Weaknesses represented existing, ongoing concerns (as previously documented in the literature), while Opportunities and Threats represented potential concerns, which, although mentioned in the literature, are yet to be documented to the same extent. Naturally, some articles contained different points relevant to more than one category, and these were therefore included in more than one section in the SWOT analysis. The outcome of this analysis can be seen in Table 2, and is described in more detail in the sections below.

Table 2. SWOT Analysis of transdisciplinary research in MBE science

Strengths	Weaknesses
Grounding of research questions and hypotheses in real world observations/need can increase impact of findings (Booth et al., 2015)	Increased ethical considerations, compared to university-based research (Felzmann, 2009)
Exposure to latest thinking/techniques (Jyrhämä et al., 2008), and latest research from other disciplines	Increased logistical considerations (Felzmann, 2009; Plummer et al., 2014).
Psychology and neuroscience can inform classroom pedagogy (Pickering & Howard-Jones, 2007; Rayner et al. 2001; Stern, 2005; Thomas et al, 2015, Roediger, 2013)	Increased difficulty controlling extraneous variables, compared to lab-based research (Plummer et al., 2014)
Pedagogy can inform psych/neuro theories (LaRusso et al., 2016) and test the applicability of theories in the real world (Stafford-Brizard et al. 2017; Kuriloff et al., 2009)	Increased time commitments can be required for all parties to collaborate more closely (Simmonds, 2014)
Psychological theories can be informed by neuroscience (Ochsner & Lieberman, 2001)	Additional training for teachers and researchers can be required, sometimes requiring both time and funding (Ansari & Coch, 2006; Simmonds, 2014; Blake & Gardner, 2007; Atkinson, 2017).
Psychological and neuroscientific findings can support educational theories and debates (Castles, Rastle & Nation, 2018; Kim, 2013; Sigman et al., 2014)	Teachers can feel less confident to contribute to project formation (Simmonds, 2014) as they are often unable to access the original research papers from each discipline (Stafford-Brizard et al., 2017).
Can provide a framework to empirically test teachers' ideas/pedagogical methods more objectively (Churches & McAleavy, 2015)	
Can develop desirable "teacher-researcher-practitioner model" for educators (Glennon et al., 2013)	
Opportunities	**Threats**
Validation of theories across disciplines (Ansari & Coch, 2006; Christodoulou & Gaab, 2009, Samuels, 2009).	Epistemic trespassing (Ballantyne, 2018). Promoting an "evidence-informed" rather than "evidence-based" model (Coldwell et al, 2017).
Increased scientific support for good practice in classroom interventions (McDaniel et al., 2013; Pickering & Howard-Jones, 2007; Roediger, 2013).	A new 'fad' (brain based 'fixes'). Poor implementing without clear understanding of underlying theory (Bokhove, 2018).
Professional development, professionalisation and empowerment of teachers as 'learning scientists' (Churches & McAleavy, 2015).	Different operational definitions of what is a successful outcome in different domains (Akkerman, Bronkhorst & Zitter, 2013; Stafford-Brizard et al. 2017).
Teacher led design of future projects (Atkinson, 2017).	Cannibalism of research funding by schools (Snow, 2015).
Structure within which to develop transdisciplinary thinking models internationally (Mishra, Koehler & Henriksen, 2011).	Relatively unpredictable nature of school's schedule, which could affect results (Plummer et al. 2014).

Opportunity for the testing of more realistic scenarios in neuroscientific research, allowing scientists to better understand how learning occurs in the classroom (Ansari & Coch, 2006; Coch & Ansari, 2009).	
Can facilitate the creation of a shared language between professionals in neuroscience, psychology and education (della Chiesa, Christoph, & Hinton, 2009; Heinze, 2003; Stafford-Brizard et al. 2017; Devonshire & Dommett, 2010)	
Reduce the difficulty for researchers of finding partnership schools (and vice versa)	
Provides a more easily understood model of cooperation between disciplines. (Bell et al., 2010).	
Demonstrating Patient and Public Involvement (PPI; Brett et al., 2014)	

Table 2. Summary of strengths, weaknesses, opportunities and threats of transdisciplinary research.

Strengths

Reciprocal benefits of transdisciplinary research in MBE science have been documented for both teachers and researchers, especially when the research questions are of interest to both researchers and educators and where benefits are mutually visible. For example, Booth et al. (2015) report researchers benefits when adopting an explicitly practice-focused research question, such as how the widely documented 'minority student achievement gap' might be reduced in Algebra 1 (an introduction to algebra course often taken by American students in eighth grade). The result of this focus was a practical intervention, 'AlgebraByExample', an intervention based on algebra assignments with interleaved worked examples that targeted common misconceptions and errors. In a random-assignment study, this was found to improve African American and Latino students' understanding of algebra and reduce the minority achievement gap. In addition to the clear educational benefits, the researchers report personal benefits in the accomplishment of university goals, including tenure-related research and graduate student dissertations. For educators, Jyrhämä et al. (2008) noted that teacher practitioners stand to benefit from exposure to the latest academic research and techniques, especially processes influencing pedagogy, which are increasingly numerous in the literature (e.g. McDaniel et al., 2013; Pickering & Howard-Jones, 2007; Rayner et al. 2001; Roediger, 2013; Stern, 2005; Thomas et al., 2015). It can be questioned in some cases, however, the extent to which such examples can be considered transdisciplinary, given that few studies report the active involvement of educators in shaping the research questions and design.

In addition to a practice-focused research question, benefits for all parties can also occur when researchers ensure *outcome variables* are of direct relevance to educators, for example attainment data (Coldwell, 2017), instead of academic tests of cognitive skills. This way, rather than attempting to measure broad academic concepts (achievement, learning), concrete and practical indicators can be used in actual classrooms. For example, McDaniel et al. (2013) showed the potential of low-stakes quizzing during science lessons to facilitate the transfer of knowledge to unseen questions on an end-of-chapter exam. Selecting measures which are of practical importance to educators is another way, therefore, to increase the value of MBE research.

Importantly, ensuring that research questions *and* outcome variables are relevant for members of one discipline does not entail any reduction in the potential for the results to inform and influence theory across other disciplines. LaRusso et al. (2016) report an investigation into the factors contributing to 'deep reading comprehension', required for success in both (US) national and international reading tasks. 'Deep reading comprehension' involves the integration of new and preexisting knowledge, as well as critical skills and a capacity for synthesis. The researchers report that three specific factors (academic language, perspective taking, and complex reasoning) all explain small but significant amounts of the variance in performance on a task of deep reading comprehension. Importantly, deep reading skills (and by extension these three contributing factors) are not frequently discussed by current theories of reading comprehension. Therefore, in addition to informing reading education through a practice-focused research question, they also produce clear theoretical implications for cognitive psychology.

A complementary strength of transdisciplinary MBE research is that it provides opportunities to validate theories over and across disciplines (Ochsner & Lieberman, 2001; Samuels, 2009) and confirms ideas applied in one domain in another. This means that theoretical research from one field can inform and shape empirical research in other disciplines (Willingham & Lloyd; 2007), such as education and psychology's constructivism finding new validation in neuroscience's neuroconstructivism (Mareschal et al., 2007; Szűcs & Goswami, 2009). It is clear that pedagogy can also inform theories in psychology and neuroscience (LaRusso et al., 2016) and test the applicability of neuroscience and psychology theories in the real world (Kuriloff et al., 2009; Stafford-Brizard, Cantor & Rose, 2017), just as psychology can help explain how and why some practices foster learning and development, whilst others do not (Ansari & Coch, 2006; Christodoulou & Gaab, 2009). For example, Sigman et al. (2014) described how an understanding of the neuroscience of visual learning could have predicted the superiority of a letter-by-letter 'phonics' system over the whole word approach to the teaching of reading, saving the field a decades-long debate (e.g. Castles, Rastle & Nation, 2018). Another less well-publicised example is motivation. Kim (2013) reviewed evidence suggesting that the emotional response to an event (our 'liking' of it) and the motivational state it produces (whether we want to repeat it) are neuroscientifically dissociable, relying on different neural substrates. Such findings may have important applications for widely-held beliefs regarding motivation in education. Kim concluded:

> *There is a need for careful reconsideration of the argument in which the school activity should be enjoyable to generate motivation because pleasure and enjoyment may not automatically lead to motivation…. To motivate the unmotivated, the learning process should be rewarding and interesting. Rewards do not have to be tangible ones. Reward in the classroom can be any stimulus which has positive expected values, including positive feedback, praise, interesting activity, utility, relevance, social support, and relatedness. (Kim, 2013, pp.5-9).*

It is clear, however, that a good deal of work remains to be done to influence practice between disciplines in a systematic manner. One successful approach to providing a systematic framework for adapting theory to practice has been to train teachers in the design and implementation of randomised controlled trials and other forms of experimental research. Churches and McAleavy (2015, p. 5) argued that the training of practitioners in scientific methods of hypothesis-testing allows for the development of a "research-informed, research-engaged and research-led" teaching profession. Transdisciplinary research partnerships can therefore be central in creating a 'teacher-researcher-practitioner model' for educators (see Glennon et al., 2013 for one example of this). Similarly, researchers might be introduced to the challenges associated with applying research hypotheses to complex, multivariate settings such as classrooms. For example, the involvement of researchers in a participatory action research scheme might allow them to consider additional variables that might not have arisen in more traditional laboratory settings (Kuriloff et al., 2009; Stafford-Brizard, Cantor & Rose, 2017).

Weaknesses

Conducting transdisciplinary research naturally brings challenges which might not normally be encountered when following more traditional academic research models. For example, research in schools may create additional ethical concerns. First, more stringent ethical principles apply to research with children compared to research involving adults. Further, Felzmann (2009) noted that the complexity of school settings creates difficulties for both the informed consent process (as multiple parties must consent for the study to take place), and also for confidentiality (given that school-based research commonly takes place in classrooms). The potentially life-long implications of educational decisions also raises important considerations (Knowland, in press; Stein et al., 2011). In addition to ethical concerns, school-based transdisciplinary research raises logistical constraints which might otherwise not be present. Plummer et al. (2014) described planning a school-based study as being akin to planning a theatrical production, requiring a large cast of characters, both on-stage and behind-the-scenes, as well as extensive rehearsals and critical feedback before the day of the 'performance' - the data collection itself. This increased logistical preparation is required because of the number of stakeholders, but also because of the increased number of extraneous variables that must be considered, and controlled for.

Any change in teacher and researcher practice may take time away from current practice, such as the need for additional training. Simmonds (2014) reported results from a survey of nearly 1,400 teachers and parents on the value of neuroscience in the classroom. When asked what would deter teachers from trying out a new activity or technique based on neuroscience, the most frequent responses were lack of time, or the activity being too time-consuming, bureaucratic or complex. This means success hinges on school leaders prioritising teacher time to engage with research-informed practice. Further training may be required for educators to feel confident in evaluating and applying research findings to their own classroom (Coldwell et al., 2017). It may also be necessary to train researchers about proper in-class protocol with children. Ansari and Coch (2006), argued that introducing trainee teachers to the methods of cognitive neuroscience will help educators understand the unique constraints of laboratory research, and so think more critically about the potential applications of such research to their own work in the future (see also Atkinson, 2017; Simmonds, 2014), just as having researchers experience real class settings would inform their appreciation of the complexities of schools. McMahon and Etchells (2018) described just such an approach to initial teacher education, however it is less clear how currently-serving teachers can be provided with the training required to become critical consumers, and users, of research evidence.

Opportunities

In addition to the strengths documented previously, there are many additional opportunities that transdisciplinary research in MBE might offer towards the development of both research and educational practice. Specifically, better transdisciplinary communication can greatly reduce many of the collaborative challenges noted above. The opportunity exists to develop a much needed brokering system for cooperation among researchers and teachers. Such a mechanism would enable schools to find researchers with expertise in priority areas and reduce the amount of time researchers devote to school recruitment. A shared and mutually understood model of cooperation and collaborative learning through partnerships between disciplines (see e.g. Bell et al., 2010) is likely to prove advantageous for all parties. Such a framework may also allow teachers to access original research papers on areas of interest, something which they are currently often unable to do, leading to a lack of confidence with assessing and contributing to research (Stafford-Brizard, Cantor & Rose, 2017; Simmonds, 2014).

As such, one important opportunity for transdisciplinary MBE is its potential to facilitate the creation of a shared language between professionals in neuroscience, psychology and education. Della Chiesa, Christoph, and Hinton (2009) wrote that such a language is necessary (though not sufficient) for a true transdisciplinary project. Stafford-Brizard, Cantor and Rose (2017) provided the example of the word ‘cognitive’, which may have different tacitly understood definitions across different fields. Amongst other things, therefore, a shared language can help all members recognise tacit knowledge within their field and move towards making this explicit for members from other disciplines (Heinze, 2013).

Building on this shared language, teachers might benefit from advice or tutoring in neuroscience or psychology (Coldwell et al., 2017), and researchers might benefit from vocabulary from the school settings. This new transdisciplinary collaborative structure promises better professional development, professionalisation, and empowerment of a new field of 'learning scientists' (Churches & McAleavy, 2015), which potentially can lead to teacher-led design of future research and research-led classroom activities (Atkinson, 2017). A focus on research which is done 'with' or 'by' research partners such as teachers, rather than 'to' them, will allow for the demonstration of Patient and Public Involvement (PPI; Brett et al., 2014) in research, which is generally regarded as research best practice and increasingly an essential requirement for research funding (Gray-Burrows et al., 2018). Global opportunities related to this type of cooperation also include the potential benefits in linking practitioners in classrooms and labs internationally, to generate research that is of more direct application in both contexts (e.g., Mishra, Koehler & Henriksen, 2011; Posch & Steiner, 2006; Steiner & Posch, 2006).

Threats

Additional training for both researchers and teachers to better understand each other's working environment might lower the risk of the threat posed by 'epistemic trespassing' - the danger of imposition of 'research-validated' strategies from above, without understanding the school context (Ballantyne, 2018). Together, teachers and researchers must find a way to co-construct a new set of protocols that favour transdisciplinary thinking. This is a threat as it requires all parties to re-imagine research without compromising the norms and protocols of their original fields of formation, including re-examining the definition of good practice. As an example, Coldwell et al. (2017) reported that teachers are more likely to trust research evidence if it is supported by other colleagues or if they can clearly see the impact on practice rather than from structured experimentation. An aim of co-constructed protocols should be to favour 'research-informed' strategies, adapted for each context by a critical and informed practitioner rather than a reliance on anecdotal evidence, or the implementation of ideas without a clear understanding of underlying theory or limitations of the original research (Bokhove, 2018).

As has already been noted, structural differences (different priorities in terms of time management, reward system, desirable outcomes) may create different operational definitions of what is a successful outcome in different domains (Akkerman, Bronkhorst & Zitter, 2013; McCandliss, Kalchman & Bryant, 2003). A threat exists, therefore, in different perceptions of what can and should be measured and the possible conflicts this can create between teacher and researcher. This sentiment was echoed by Stafford-Brizard and colleagues (2017) when they noted, "the evolution will no doubt create tension on both sides of the bridge as each side will prioritize meeting standards for rigor in their respective fields" (p. 9). This suggests that success criteria for educational outcomes may have to be renegotiated between parties before beginning the research.

An important threat to consider in all transdisciplinary research is that many funding agencies do not yet separately categorise transdisciplinary studies. In a growing number of cases, funding opportunities are offered to different actors with interests in student learning outcomes, enhancing the probability of players from one field (researchers in labs; teachers in schools), encroaching on spaces traditionally associated with another, potentially inducing competition instead of collaboration. Researchers as well as teachers may therefore be wary of the potential for cannibalism of funding from other agents (Snow, 2015). Beyond potential impacts on funding, threats to the model may involve the fear of a loss of resources, intellectual property or simply control over one's professional sphere. All are likely to only be rectified through the gradual development of mutual trust between all parties involved in the process.

Other threats to this model relate to the rhythms and work cycles of different professions. Researchers often meticulously plan experiments, data gathering and analysis stages of their work whereas teachers' daily success often relies on being flexible and adapting to the needs of students in unplanned ways. This suggests that while a research project might be agreed upon, unpredictable events in the environment might alter the ability to follow through with the agreed-upon methodology or timetable. Plummer and colleagues (2014) suggested that the relatively unpredictable nature of each school's schedule need to be taken into consideration and, where possible, the padding of additional time to take into account the variability in teachers' work days.

SWOT summary

The SWOT analysis clearly identifies more reasons to support a model of transdisciplinary teacher-researcher engagement than to ignore it. On the whole, we were able to identify more strengths of a transdisciplinary research model than we were weaknesses, and more opportunities than threats, within the published MBE literature. Importantly, we were also able to identify many opportunities which have not yet been fully realised, demonstrating the requirement for further work to facilitate a more widespread adoption of transdisciplinary research practices. A central recurring theme of our SWOT analysis, supporting the original conclusions of the working party, was that many of the opportunities could be realised, and the threats minimised or removed altogether, if communication between disciplines were facilitated, and partnerships between researchers and teachers were allowed to form in as frictionless a manner as possible. At present, however, few tools exist to allow for this communication.

Specifically, we argue that no tools currently exist to allow for researchers and schools with complementary interests (who would mutually benefit from the formation of a research partnership) to find one another. In economics, 'search and matching theory' (e.g. Pissarides, 2000) describes the constraints governing the formation of mutually beneficial relationships. Within this framework, Stigler (1961; 1962) posited that if agents cannot instantly find information they are looking for, they will continue to search for it only for as long as they believe the benefits of acquiring the information will outweigh the challenges or costs associated with the search – the 'search frictions'. What is notable from taking an economic view of our transdisciplinary SWOT analysis is a lack of any tools to reduce the search frictions for educators and researchers willing to engage in collaboration. It seems highly likely that more efficient matching of researchers with schools/teachers who share mutual interests will result in further advances in the development of a true transdisciplinary science.

While the need for increased communication between teachers and researchers has been suggested before through teaching schools (Hinton & Fischer, 2008; Glennon et al., 2013), and in action research models (Kuriloff et al., 2009), an open, free, multilingual, international platform to encourage the formation of such partnerships does not yet exist. We now describe a system which seeks to overcome some of the current roadblocks in the transdisciplinary MBE science research.

‘UNIFIED’: A platform to connect schools and researchers

Our proposed system for reducing the search frictions between schools and researchers envisages the creation of an online knowledge community where teachers and researchers can come together to communicate and collaborate in a safe, constructive environment and on an equal footing. The network, named ‘UNIFIED’ (the name deriving from the desire to connect ‘Uni’ and ‘Ed’), is based on the ‘Craigslist’ website design (UK-based readers may be more familiar with ‘Gumtree’, which uses a similar system). Craigslist is a ‘classified ads’ website which provides a multi-sided platform (Hagiu & Wright, 2015), where both those offering and seeking services are able to post. For example, in the case of buying a house, a buyer might advertise their interest in a particular property type within a specific location, whilst sellers will list the features and location of the house they have available. The platform will then allow for listings from either side which demonstrate similar interests to be linked with one another. Multi-sided advertising platforms have been found to reduce friction costs in other areas, such as employment and housing rental (Kroft & Pope, 2014), by making it easier for parties on either side to connect with each other.

A Craigslist advert (from either buyer or seller) consists of a subject line, keyword-encoded metadata tags (selected labels from a pre-defined list summarizing the advert), and a body of text. Advert authors are able to provide tags on location and the type of service offered or required. Importantly, tags can be "nested," meaning one tag can enclose one or more other tags, so the location tag allows for the nesting of a regional location inside a country tag, for example, or a section on job listings can be subdivided into a number of different fields. The ‘tags’ therefore provide a nested framework within which parties from both sides are able to more easily search for, locate, and form a relationship with one another. A similar system would allow for both teachers and researchers to advertise for partnerships, based on tags illustrating areas of shared priority or interest. The subsequent transdisciplinary partnerships facilitate PPI, by allowing for all parties to contribute collaboratively to the research design from the very start of the process.

System design

As in traditional multi-sided advertising applications, users will start specifying some basic pieces of information, such as their name, profession, institution, location and contact details. They will then be guided through a process allowing them to progressively define their interests and needs, using a series of nested tags. A set of questions will be presented. Crucially, feedback will be provided to the user after each of their answers, to either: a) refine their answer if needed, or b) move on to the next question. Questions will be tailored to the users' profile. Researchers and teachers will be presented with slightly different questions that mirror each other, and which are adapted to the user's background, while encouraging them to think from the other's perspective. An example is provided in Table 3.

Table 3. Example of questions included in the process of profile creation.

Teacher	Researcher
RESEARCH QUESTION. Do you know which research topic you would like to investigate? (**Yes**/**No**)	RESEARCH QUESTION. Do you already have a clear research question or ongoing research project? (**Yes**/**No**)
If **No**, that's ok, we will help you to identify key words to delimit your potential project. The list below contains tags, that is to say short words characterising your potential project. You can click on each word to have the corresponding definition. If **Yes**, please summarise your research question	If **No**, that's ok, we encourage you to develop the research project and questions with real teachers in real schools! If **Yes**, please summarise your research question. Feel free to include links to any previous related work. Note that we encourage researchers to collaborate with schools on their research questions, so

	please be flexible in this regard.
TOPIC TAGS - Please select at least 2 or 3 tags (or more if you prefer) in the list below to define your topic or areas of main interest	
If you can't find a tag that you are looking for - please create your own using the 'create tag' option (though bear in mind that if this is too specific then other people may be less likely to find it)	
WORKING THEORY/HYPOTHESIS. Do you have a theory or hypothesis about your topic (why Johnny can't read; why bullying is more prevalent in the younger years; why bilingual education is rejected by some parents...Whatever the topic)? (**Yes**/**No**)	WORKING THEORY/HYPOTHESIS. Do you have a theory or hypothesis which informs your work (whatever the topic)? This will help potential research partners understand more clearly the sorts of questions that you are investigating (**Yes**/**No**)
If **No**, that's ok, that's what the researcher is here for! There are usually lots of possible answer to the problems we find in schools, we'll help you consider the possibilities and narrow down the focus. If **Yes**, please describe it briefly	If **No**, that's ok, we encourage you to develop the project with real teachers in real schools! However we do recommend that all projects in schools have a sound theoretical and evidential base for the work, in order to make the research as useful as possible to all concerned. If **Yes**, please describe it briefly, linking to any relevant previous work

Table 3. Example questions from profile creation process. Answers to a sequence of eight will result in the creation of a profile containing the selected keyword 'tags', which are searchable within the platform, as well as other key information for the formation of research partnerships (ethics approval, funding, working hypothesis, prior experience etc.) Teachers and researchers will therefore be able to identify other profiles with shared tags as promising targets for a research partnership.

The example in Table 3 illustrates some key points of the platform. First, teachers and researchers are encouraged to answer with the same format. In the first question, they are asked to select key tags (with their accompanying definition), to define their broad area of interest. Tags and definitions will be extracted from an established glossary, such as the one created by the Organisation for Economic Co-operation and Development (2018), building a common vocabulary, and facilitating matches. Note that teachers or researchers will not have to understand each definition or concept perfectly: they will be able to discuss it further and refine their ideas once a partnership has been formed. The common list of tags aims at providing a shared language base for communication, ensuring the same terms are used across the platform. This will facilitate navigation between profiles, visibility, and the identification of potential partners. Additional tags will refer to the practical details of the project. In the first level of tags, researchers and schools would be able to select terms relevant to their research topic, the potential age of participants, their location. For example, a teacher's profile may contain the tags: "motivation" (research topic), "USA" (location) , "11 to 16" (pupils' age). In the process of searching within the database, users would be able to select and organise the different profiles according to specific tags. For example, a teacher could look for any researcher working in his/her surrounding geographical area (an interactive map could be added to facilitate visual representation). Or she/he might prioritise a specific research topic, and only search for researchers working on motivation. Tags would be 'nested' within different levels to allow parties to express interest in more specialised areas (see Figure 1). When browsing profiles and searching for specific tags (or a combination of tags), users will therefore be able to see at a glance whether another user has compatible research interests, an already formed research question, and how flexible they are regarding the practicalities of the proposed study.

Geographic location:

- Countries
    - o States/counties
        - § Towns/cities

Key areas of interest:

- Attendance
    - o Student
    - o Teacher
- Behaviour management
- Cognition
    - o Attention
    - o Memory
    - o Motivation
        - § Intrinsic
        - § Extrinsic
        - § Goals
    - o Language
        - § Reading
        - § Bilingualism
        - § EAL

Figure 1: Example of a 'nested' system of tag organisation. Level 1 tags contain a number of nested subdivisions (e.g. A Level 4 tag such as 'Intrinsic motivation' is nested within three larger divisions 'Key areas of interest/Cognition/Motivation')

Note that users will be free to be more or less specific in their answers. That is to say, teachers will be able to publish their profile even without having selected any tags (beyond the mandatory information required for the profile, which will include the location of the projects and the age and school levels of the potential participants). Indeed, it will be important to allow flexibility in developing a project *together with* a research partner, instead of selectively filtering offers that only perfectly match with a user's interest. Researchers will also be encouraged not to define their final research question before finding a school partner. Equally, although they will be asked whether they have existing ethical approval for work in schools, this will not be made a prerequisite for researcher registration, as ethical protocols may be more effectively planned collaboratively with school partners (perhaps using a 'Collaborative project specification' - see the 'Piloting phase: latest updates and next steps' section. The final profile of researchers and educators will contain the same categories of information (even if some categories are left undefined, or "empty") to facilitate comparisons between profiles. This process will therefore create a searchable database, allowing users from all sides to identify parties with reciprocal interests and complementary expertise, which means contact can be made at a much earlier stage of the planning process.

Following the creation of profiles, three central functions are envisaged to facilitate interdisciplinary communication: a) searching for other users within specific tags (or combinations of tags), b) allowing for messaging/chat between members and c) creating a 'group' - similar to a group in other social/professional networks - that members with specific interests can be invited to, and can chat within. Group topics will be defined using the same, searchable tags as individual profiles, allowing groups to also be searched and viewed within the platform. From within these groups, the formation research collaborations will be encouraged through the scaffolded creation of a joint project specification (see 'Piloting Phase: latest updates and next steps' section).

External resources and additional documents (such as links to previous research on topics, introductory 'primers', or guidance on research design) might also be used when trying to define a research question. For example, the concept of a research question might be unfamiliar to teachers or the concept of "differentiated instruction" might be unfamiliar to a researcher. Both sides might be interested in a general topic, such as motivation, or attention, but might have difficulties formulating what they actually would like to know in terms of a research question ("How do I promote attention in my classroom, that is to say, how do I encourage children to stay focused on their task, without getting up or engaging in conversations before it is done?"). One potential auxiliary benefit of the platform may therefore be the improved dissemination of information between fields (although it does not aim to provide or act as a guarantor of the current state of knowledge about learning sciences *per se)*. For example, researchers and teachers who "matched" would be encouraged to share knowledge more effectively, ideally within a group which would be visible to other members as well. Researchers, for example, could provide teachers with access to scientific articles, or disseminate articles and summaries that they consider is representative of their field, and reliable (perhaps capitalizing on existing resources such as the EEF toolkit in the UK). As part of the registration process, researchers will be asked to link to relevant or previous research (open access links will be encouraged), and such links will be viewable to educators through their profile. Teachers, in turn, will be asked to point toward potential variables, or factors that might influence pupils' learning and outcomes and have not been considered yet by the researcher.

Care must be taken to carefully define the ethical rules associated with the platform (e.g. privacy, data protection, profile updating and curation, informed consent across a range of stakeholders etc.). This will need to be a point for further discussion between members of each community (web design, educators, researchers), in order to make sure that basic ethical rules are satisfied for all fields (see Box 1 for a list of open questions regarding the operation of the platform). Ethical considerations will also be highlighted in a set of guidelines, specifying what the platform can and cannot provide as a service. For example the guidelines could include the following main points: *What is the platform for? Who can use the platform? What is the platform not for?* It will be important to build an environment where users feel safe, and rely on each other to provide an exchange of information. In such an environment, the benefits of transdisciplinarity are likely to be realised most strongly for teachers, researchers and, ultimately and most importantly,students.

Overall we believe that the platform holds great promise for the development of MBE communication and research as a transdisciplinary endeavour, and therefore in realising many of the opportunities identified in the SWOT analysis. Both teachers and researchers stand to benefit from the ability to form research partnerships more efficiently and collaboratively than has often been the case in the past. Using Shonkoff's (2000) terminology, we hope that the platform will help "reasonable hypotheses" to flourish. That is to say, that it will anchor projects in established knowledge, while allowing for flexibility to adapt to complex social contexts and move beyond what is already known. Our hope is that such reasonable hypotheses will help MBE practitioners from all sides to navigate and co-operate successfully in our ever-evolving educational settings, while maintaining a scientific framework for the validation of systematically vetted ideas.

Piloting Phase: latest updates and next steps

After the precise structure of the platform was agreed upon, a prototype design was shared within, and critiqued by the group. After additional refinement (addition of new tags, modifications to the user-friendly elements, comparisons with existing platforms around the world), then a final web design was plotted and a webmaster was contracted using seed money provided by one of the group members (through Connections/Conexiones in Ecuador; see www.thelearningsciences.com). The webmaster worked with two of the authors to come to an agreement of the expectations on both sides and new needs arose. The new needs included "branding" the webpage with a logo, which was also contracted (through UpWork). At the time of writing, the webpage is being constructed and will be piloted in the summer of 2019. The group is seeking grants from Reimagine Education, Society For Neuroscience, EdTech funding organisations, UNESCO and others with the goal of long term sustainability. We envisage a relatively low cost basic structure that can be maintained for around $100 a year, plus a retained webmaster who can quickly make any changes required ($1200 per year), and potentially, a moderator/reviewer/liaison officer (roughly $3000 per year).

An important further stage of development for the platform will come when the live platform begins beta testing, and connections between schools and researchers start to be made. The formation of projects will be guided by a 'Collaborative project specification' document, a template which will guide schools and researchers step-by-step through a collaborative process of research design, creating a detailed project specification which can then be jointly followed. This will be refined based on the needs and feedback of our early users. For example, the template contains prompts regarding the study methodology, the logistics in relation to the school site and timetable, specific ethical concerns arising from the research or the setting, and so on. It is likely that the template will be initially suggested to users as an informal checklist, however greater rigour and accountability (should this be deemed needed) could easily be attained by formalising these collaborative steps, through the platform.

Many practical questions about UNIFIED remain. The question arises as to how the UNIFIED platform will serve its function to unify researchers and teachers, while simultaneously remaining independent and autonomous from individual research projects. One solution is that global bodies such as IMBES and EARLI accept the role of joint caretakers, which would reduce the likelihood of any single government or university dominating research agendas. A joint caretaker role, for IMBES and EARLI for example, would also eliminate concerns about sustainability, which, in academia is often subjective to the institutional priorities of the moment. Others will question the sustainability from a financial perspective, despite the very low operational costs, it would take at least $5000 a year to upkeep the platform and create a skeleton staff to monitor exchanges. As such a platform encourages quality scientific research, it is likely, though not guaranteed, that financing could be found through organizations with shared interests. Other concerns speak directly to the challenges and opportunities offered by a more globally connected world in which there remain unclear legal guidelines as to international responsibility in cooperative academic efforts, such as UNIFIED. Legal questions have yet to be resolved because legal boundaries have yet to be defined, in many cases. Having said that, other platforms such as 'Craigslist' and 'LinkedIn' share design elements with UNIFIED and have functioned well for years. User protection is also of paramount importance. The registration process specifies that we prefer institutional email addresses which can be validated, and the collaborative project specification contains the values and criteria for use of the site, as well as suggested prompts to ensure the safeguarding of both sides. Finally, questions of actual utility can only be answered once the pilot phase has been completed. This means that once up and running, UNIFIED will have to be tested and likely modified once again to be as user friendly and practical as possible. The critical assessment of this model will be vital to its continued use.

In addition to building and operating the platform, a good deal of work remains to be done in the implementation and publicising of the system. Efforts will be required to encourage all parties to engage with the platform, and the experience of transdisciplinary colleagues will be essential in anticipating any roadblocks. The authors would be very pleased to hear from any other members of the MBE community who have ideas or suggestions regarding the further development of the system, as we build towards testing the pilot system. Despite all of the potential challenges facing UNIFIED, it is clear that the development phase of this idea can already claim success, at least in moderation. Neuroscientists, teachers, psychologists, and educational technology experts have united from both IMBES and EARLI affiliations, as well as a half dozen different universities and a number of schools from around the world, to collaborate on this creative process, thanks to a conference sponsored by another organization, the Wellcome Foundation. Rather than simply acknowledging the problems in communication and collaboration in MBE, as a group, we have explored and possibly contributed to an international, transdisciplinary solution that we now submit to the global community for scrutiny.

<u>Box 1. Open questions</u>

- How self-regulated should such a system be? How can (and should) research and partnerships created through the platform be quality controlled, or monitored (if at all)?
- What costs and labour requirements are associated with running the platform, and how are these best provided for?
- How can enough participants from all fields be encouraged to join in the initial stage for the platform to develop momentum?
- What kind of incentives are needed on either side to encourage the successful use of the platform (and greater transdisciplinary work in general)?
- How can we ensure a more systematic promotion of such partnerships, and of the platform, both in the research and teaching worlds?
- What additional ethical and logistical constraints are created by designing research in a transdisciplinary manner using the platform? How can they be minimised?
- What factors will help to build trust between parties on all sides?

References:

Akkerman, S. F., Bronkhorst, L. H., & Zitter, I. (2013). The complexity of educational design research. Quality & Quantity, 47(1), 421-439. doi:10.1007/s11135-011-9527-9

Ansari, D., & Coch, D. (2006). Bridges over troubled waters: Education and cognitive neuroscience. *Trends in Cognitive Sciences*, *10*(4), 146-151. doi:10.1016/j.tics.2006.02.007

Atkinson, D. (2017). Embedding research activities in school. Impact. *Interim issue*.

Ballantyne, N. (2018). Epistemic trespassing. *Mind*. doi.org/10.1093/*mind*/fzx042.

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: Models, tools, and challenges. *International journal of science education*, 32(3), 349-377. doi:10.1080/09500690802582241

Blake, P. R., & Gardner, H. (2007). A first course in mind, brain, and education. *Mind, Brain, and Education*, *1*(2), 61-65. doi:10.1111/j.1751-228x.2007.00007.x

Bokhove, C. (2018). This is the new myth. *Impact*, *1*.

Booth, J. L., Oyer, M. H., Paré-Blagoev, E. J., Elliot, A. J., Barbieri, C., Augustine, A., & Koedinger, K. R. (2015). Learning algebra by example in real-world classrooms. *Journal of Research on Educational Effectiveness*, *8*(4), 530-551.

Brett, J., Staniszewska, S., Mockford, C., Herron-Marx, S., Hughes, J., Tysall, C. and Suleman, R. (2014) 'Mapping the impact of patient and public involvement on health and social care research: A systematic review'. *Health Expectations*, 17 (5), 637–50. doi:10.1111/j.1369-7625.2012.00795.x

Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest*, *19*(1), 5-51. doi:10.1177/1529100618772271

Christodoulou, J. A., & Gaab, N. (2009). Using and misusing neuroscience in education-related research. *cortex*, *45*(4), 555-557.

Churches, R., & McAleavy, T. (2015). Evidence That Counts--What Happens When Teachers Apply Scientific Methods to Their Practice: Twelve Teacher-Led Randomised Controlled Trials and Other Styles of Experimental Research. *CfBT Education Trust*.

Coldwell, M., Greany, T., Higgins, S., Brown, C., Maxwell, B., Stiell, B., ... & Burns, H. (2017). *Evidence-informed teaching: an evaluation of progress in England. Research report July 2017 (DFE-RR696)*. Department for Education.

della Chiesa, B., Christoph, V., & Hinton, C. (2009). How many brains does it take to build a new light: Knowledge management challenges of a transdisciplinary project. *Mind, Brain, and Education*, 3(1), 17–26. doi:10.1111/j.1751-228x.2008.01049.x

Felzmann, H. (2009). Ethical issues in school-based research. *Research Ethics Review*, *5* (3), 104–109. doi:10.1177/174701610900500304

Glennon, C., Hinton, C., Callahan, T., & Fischer, K. W. (2013). School-Based Research. *Mind, Brain, and Education*, 7(1), 30-34. doi.org/10.1111/mbe.12004

Gray-Burrows, K. A., Willis, T. A., Foy, R., Rathfelder, M., Bland, P., Chin, A., Hodgson, S., Ibegbuna, G., Prestwich, G., Samuel, K., & Wood, L. (2018). Role of patient and public involvement in implementation research: a consensus study. *BMJ Qual Saf*, bmjqs-2017. doi: 10.1136/bmjqs-2017-006954.

Guerriero, S. (2014). Teachers' pedagogical knowledge and the teaching profession. *Teaching and Teacher Education*, *2*(1), 7

Hagiu, A., & Wright, J. (2015). Multi-sided platforms. *International Journal of Industrial Organization*, *43*, 162-174.

Hattie, J. (2012). *Visible learning for teachers: Maximizing impact on learning*. Routledge.

Heinze, T. (Ed.). (2013). *Kommunikationsmanagement: Wissen und Kommunikation in Bildung, Kultur und Tourismus*. Springer-Verlag.

Hinton, C., & Fischer, K. W. (2008). Research schools: Grounding research in educational practice. *Mind, Brain, and Education*, *2*(4), 157-160.

Howard-Jones, P. (2014). Neuroscience and education: myths and messages. *Nature Reviews Neuroscience*, 15 (12), 817 – 824. doi.org/10.1038/nrn3817

Humphrey, A. (2005). SWOT analysis for management consulting. Palo Alto, CA: SRI Alumni Newsletter (December). SRI International

Jyrhämä, R., Kynäslahti, H., Krokfors, L., Byman, R., Maaranen, K., Toom, A., & Kansanen, P. (2008). The appreciation and realisation of research-based teacher education: Finnish students' experiences of teacher education. *European Journal of Teacher Education*, *31*(1), 1-16. doi: 10.1080/02619760701844993

Kim, Sung, I. (2013). Neuroscientific model of motivational process. *Frontiers in Psychology*, *4*(MAR), 1–12. doi.org/10.3389/fpsyg.2013.00098

Knowland, V.C.P. (in press). Educational neuroscience: Ethical perspectives. In M.S.C. Thomas, D. Mareschal & I. Dumontheil (Eds.). *Educational neuroscience: Development across the lifespan*. London: Routledge

Kroft, K., & Pope, D. G. (2014). Does online search crowd out traditional search and improve matching efficiency? Evidence from Craigslist. *Journal of Labor Economics*, *32*(2), 259-303.

Kuriloff, P., Reichert, M., Stoudt, B., & Ravitch, S. (2009). Building research collaboratives among schools and universities: Lessons from the field. *Mind, Brain, and Education*, *3*(1), 34–44. doi.org/10.1111/j.1751-228X.2008.01051.x

LaRusso, M., Kim, H. Y., Selman, R., Uccelli, P., Dawson, T., Jones, S., & Snow, C. (2016). Contributions of academic language, perspective taking, and complex reasoning to deep reading comprehension. *Journal of Research on Educational Effectiveness*, *9*(2), 201-222. doi:10.1080/19345747.2015.1116035

Leavy, P. (2016). *Essentials of transdisciplinary research: Using problem-centered methodologies*. Routledge.

Lou, Z. & Qin, Z. (2012). SWOT analysis of functions of Chinese universities. *IERI procedia*, 2, 253-257

Mareschal, D., Johnson, M. H., Sirois, S., Thomas, M. S., Spratling, M., & Westermann, G. (2007). Neuroconstructivism: How the brain constructs *cognition* (Vol. 1). *Oxford University Press* (1). doi:10.1017/s0140525x0800407x

McCandliss, B. D., Kalchman, M., & Bryant, P. (2003). Design experiments and laboratory approaches to learning: Steps toward collaborative exchange. *Educational Researcher*, *32*(1), 14-16. doi:10.3102/0013189x032001014

McDaniel, M. A., Thomas, R. C., Agarwal, P. K., McDermott, K. B., & Roediger, H. L. (2013). Quizzing in middle-school science: Successful transfer performance on classroom exams. *Applied Cognitive Psychology*, *27*(3), 360-372. doi:10.1002/acp.2914

McMahon, K., & Etchells, P. J. (2018). Interdisciplinary bridging: A design-based research approach to enhancing the learning sciences in primary Initial Teacher Education. *Profession*, *18*(19), 19.

Mishra, P., Koehler, M. J., & Henriksen, D. (2011). The seven trans-disciplinary habits of mind: Extending the TPACK framework towards 21st century learning. *Educational Technology*, 22-28.

Ochsner, K. N., & Lieberman, M. D. (2001). The emergence of social cognitive neuroscience. *American Psychologist*, 56(9), 717. doi:10.1037/0003-066x.56.9.717

Ofsted. (2019). *The education inspection framework.* London: Ofsted

Organisation for Economic Co-operation and Development (2018). Glossary: concepts and abbreviations. Retrieved from http://www.oecd.org/education/ceri/19622348.htm

Owen, H. (2008). *Open space technology: A user's guide*. Berrett-Koehler Publishers.

Paulus, P. B., & Nijstad, B. A. (Eds.). (2019). *The Oxford Handbook of Group Creativity and Innovation*. Oxford Library of Psychology.

Paulus & Nijstad, 2019

Payne, S. L., & Calton, J. M. (2017). Towards a managerial practice of stakeholder engagement: Developing multi-stakeholder learning dialogues. In *Unfolding stakeholder thinking* (pp. 121-135). Routledge.

Pickering S. J, & Howard-Jones, P. A. (2007) Educators' views of the role of neuroscience in education: a study of UK and international perspectives. *Mind, Brain and Education*,1, 109-13. doi:10.1111/j.1751-228x.2007.00011.x

Pissarides, C.A (2000). *Equilibrium Unemployment Theory* (2nd ed.). MIT Press.

Plummer, B. D., Galla, B. M., Finn, A. S., Patrick, S. D., Meketon, D., Leonard, J., & Duckworth, A. L. (2014). A Behind-the-Scenes Guide to School-Based Research. *Mind, Brain, and Education*, *8*(1), 15-20. doi:10.1111/mbe.12040

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., ... & Duffy, S. (2006). Guidance on the conduct of narrative synthesis in systematic reviews. *A product from the ESRC methods programme Version*, *1*, b92.

Posch, A., & Steiner, G. (2006). Integrating research and teaching on innovation for sustainable development. *International journal of sustainability in higher education*, *7*(3), 276-292.

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2001). How psychological science informs the teaching of reading. *Psychological science in the public interest*, *2*(2), 31-74. doi.org/10.1111/1529-1006.00004

Roediger, H. L. (2013). Applying cognitive psychology to education: Translational educational science. *Psychological Science in the Public Interest*, *14*(1), 1-3. doi.org/10.1177/1529100612454415

Romero-Gutierrez, M., Jimenez-Liso, M. R., & Martinez-Chico, M. (2016). SWOT analysis to evaluate the programme of a joint online/onsite master's degree in environmental education through the students' perceptions. *Evaluation and program planning*, 54, 41-49.

Rose, L. T., Daley, S. G., & Rose, D. H. (2011). Let the questions be your guide: MBE as interdisciplinary science. *Mind, Brain, and Education*, *5*(4), 153–162. doi.org/10.1111/j.1751-228X.2011.01123.x

Samuels, B. M. (2009). Can the differences between Education and Neuroscience be overcome by Mind, Brain, and Education? *Mind, Brain, and Education*, *3*(1), 45–55. doi.org/10.1111/j.1751-228X.2008.01052.x

Science for all. (2010). The public engagement triangle. Online at https://webarchive.nationalarchives.gov.uk/20121106091336/http://scienceandsociety.bis.gov.uk/all/files/2010/10/PE-conversational-tool-Final-251010.pdf

Shonkoff, J. P. (2000). Science, policy, and practice: Three cultures in search of a shared mission. *Child development*, *71*(1), 181-187. doi:10.1111/1467-8624.00132

Sigman, M., Peña, M., Goldin, A. P., & Ribeiro, S. (2014). Neuroscience and education: prime time to build the bridge. *Nature Neuroscience*,*17* (4), 497–502. doi.org/10.1038/nn.3672

Simmonds, A. (2014). *How neuroscience is affecting education: Report of teacher and parent surveys*. Wellcome Trust.

Snow, C. E. (2015). 2014 Wallace Foundation Distinguished Lecture: Rigor and realism: Doing educational science in the real world. *Educational Researcher*, *44*(9), 460-466. doi:10.3102/0013189x15619166

Stafford-Brizard, K. B., Cantor, P., & Rose, L. T. (2017). Building the bridge between science and practice: Essential characteristics of a translational framework. *Mind, Brain, and Education*, *11*(4), 155-165. doi:10.1111/mbe.12153

Stein, Z., Della Chiesa, B., Hinton, C., & Fischer, K. W. (2011). Ethical issues in educational neuroscience: Raising children in a brave new world. *The Oxford handbook of Neuroethics*, 803-822.

Steiner, G., & Posch, A. (2006). Higher education for sustainability by means of transdisciplinary case studies: an innovative approach for solving complex, real-world problems. *Journal of Cleaner Production*, *14*(9-11), 877-890.

Stern, E. (2005). Pedagogy meets neuroscience. *Science*, 310(5749), 745-745. doi: 10.1126/science.1121139

Stiggelbout, A. M., Pieterse, A. H., & De Haes, J. C. J. M. (2015). Shared decision making: concepts, evidence, and practice. *Patient education and counseling*, 98(10), 1172-1179.

Stigler, G. J. (1961). The economics of information. *Journal of political economy*, *69*(3), 213-225.

Stigler, G. J. (1962). Information in the labor market. *Journal of political economy*, *70*(5, Part 2), 94-105.

Szűcs, D., & Goswami, U. (2007). Educational neuroscience: Defining a new discipline for the study of mental representations. *Mind, Brain, and Education*, *1*(3), 114-127, doi:10.1111/j.1751-228x.2007.00012.x

Thomas, M. S. C., Kovas, Y., Meaburn, E. L., & Tolmie, A. (2015). What can the study of genetics offer to educators? *Mind, Brain, and Education*, *9*(2), 72–80. doi.org/10.1111/mbe.12077

Tokuhama-Espinosa, T. (2010). *Mind, brain, and education science: A comprehensive guide to the new brain-based teaching.* WW Norton & Company.

van Wijngaarden, J. D., Scholten, G. R., & van Wijk, K. P. (2012). Strategic analysis for health care organizations: the suitability of the SWOT-analysis. *The International journal of health planning and management*, 27(1), 34-49.

Varma, S., McCandliss, B. D., & Schwartz, D. L. (2008). Scientific and pragmatic challenges for bridging education and neuroscience. *Educational researcher*, *37*(3), 140-152.

Weihrich, H. (1982). The TOWS matrix—A tool for situational analysis. *Long range planning*, *15*(2), 54-66.

Willingham, D. T., & Lloyd, J. W. (2007). How educational theories can use neuroscientific data. *Mind, Brain, and Education*, *1*(3), 140-149.